

562. In contrast, as mentioned above, the existence of a sufficient fluid pressure in the internal flow portion 569 results in the above-described resilient outward deformation of the lip 571 in order to allow normal one-way flow through the reed check valve member 562, as illustrated by flow arrow 577 in FIG. 23. As mentioned above, such a reed check valve can also be used in non-bladder type pumps, as well as the exemplary bladder-type pump shown in the drawings.

It should be noted that other check valve configurations or arrangements were tried in order to render the pump capable of functioning in non-vertical or inverted orientations, such as a ball-and-seat check valve arrangement similar to that described above and shown in FIG. 2, but having a spring-loaded return for resiliently urging the ball against its seat in order to seal the ball against back-flow pressure. However, such an arrangement was found to be unsatisfactory due to the relatively high level of pressure or static head necessary to overcome the return spring during normal one-way flow. As a result, pumps having such an arrangement were found to be lacking in performance in applications where insufficient static head was present in a well, tank, or other vessel in order to overcome the force of the return spring. Thus, the above-described reed-type check valve was tried and it was found, rather surprisingly, that such a check valve member, which is normally primarily used in gas flow applications, performed very satisfactorily in various applications for the pump 520.

Referring to FIG. 19, an additional feature is illustrated, which represents a modification over the basic design of the fluid sampling pump 20 shown in FIG. 2. Such additional feature is provided by way of an anti-chafe sleeve 579 disposed between the pump body 560 and the pump bladder 590, in a generally surrounding relationship with the pump bladder 590. The anti-chafe sleeve 579 is open to fluid flow at one or both of its ends and is provided for purposes of protecting the pump bladder 590 from wear or destruction resulting from excessive laterally-outward expansion or from abrasive chafing or rubbing contact with the interior of the pump body 560. Although not essential to the operation of the pump 520, the provision of the anti-chafe sleeve 579 has been found to significantly decrease the wear on the pump bladder 590, thus increasing the life of the bladder 590 and the pump 520 in many applications.

FIG. 24 illustrates an additional embodiment of the present invention, wherein the exemplary pump 520 is installed in a well drilled substantially horizontally, for example. In the embodiment of FIG. 24, the pump inlet 522 is attached in fluid communication with one end of a flexible hose 790 having its opposite, open inlet end 794 submerged in the liquid 716. This arrangement allows for pumping from such a horizontal, or near-horizontal, well to a very low liquid level. Such low level can be even further minimized by providing a hose inlet weight 792 at the hose inlet end 794 in order to enhance the downward deflection of the flexible hose 790. In either example, a reed check valve, such as that described above, can be provided either in the pump inlet 522 or in the hose inlet end 794, as well as in the pump outlet, if deemed necessary in a given application of the invention.

Although various examples of an application of the invention in a bladder-type pump have been shown and described for purposes of illustration herein, one skilled in the art will readily recognize that the invention is

equally applicable to a wide variety of other types of pumps, including pumps not having a flexible bladder.

The foregoing discussion discloses and describes exemplary embodiments of the present invention. One skilled in the art will readily recognize from such discussion, and from the accompanying drawings, that various changes, modifications and variations may be made therein without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A gas-actuated liquid pump adapted to be at least partially submerged within a liquid to be pumped, said liquid pump comprising: a pump body, a liquid inlet, a liquid outlet, a gas chamber in said pump body for receiving a gas therein, a liquid chamber in said pump body in fluid communication with said liquid to be pumped longitudinally through said inlet, a flexible bladder isolating said gas chamber from said liquid chamber, said flexible bladder being selectively deformable in response to changes in the pressure of said gas in order to cause said liquid to flow through said liquid chamber from said inlet to said outlet, inlet check valve means between said inlet and said liquid chamber for allowing one-way flow of said liquid therethrough from said inlet to said liquid chamber and for substantially preventing back-flow of said liquid therethrough from said liquid chamber to said inlet regardless of the vertical, horizontal, non-vertical, or inverted orientation of said pump, outlet check valve means between said outlet and said liquid chamber for allowing one-way flow of said liquid therethrough from said liquid chamber to said outlet and for substantially preventing back-flow of said liquid therethrough from said outlet to said liquid chamber regardless of the vertical, horizontal, non-vertical, or inverted orientation of said pump, and anti-chafe means generally surrounding said flexible bladder and disposed between said flexible bladder and the interior of said pump body for substantially preventing contact of said flexible bladder with said pump body, each of said inlet and outlet check valve means including a reed-type check valve member having a body portion having an internal flow opening extending therethrough, a flange portion at one end of said body portion surrounding said internal flow opening in sealing engagement with said pump adjacent said inlet, and a lip portion at the opposite end of said body portion resiliently deflectable between an open position in communication with said internal flow opening for allowing said one-way flow therethrough and a closed position blocking off said internal flow opening for substantially preventing said back-flow therethrough, said lip portion being resiliently biased toward said closed position, said lip portion being resiliently deflectable to said open position in response to a predetermined liquid pressure within said internal flow opening, said lip portion being further biased toward said closed position by a back-pressure exerted thereon from within said liquid chamber, said reed-type check valve member including a generally frusto-conical tapered portion converging toward said opposite end of said body portion and defining said lip portion at said opposite end, said anti-chafe means including an anti-chafe sleeve disposed between said flexible bladder and the interior of said pump body in a laterally generally-surrounding relationship with said flexible bladder, said anti-chafe sleeve having at least one open unsecured end portion thereon